A very preliminary study on global misalignment

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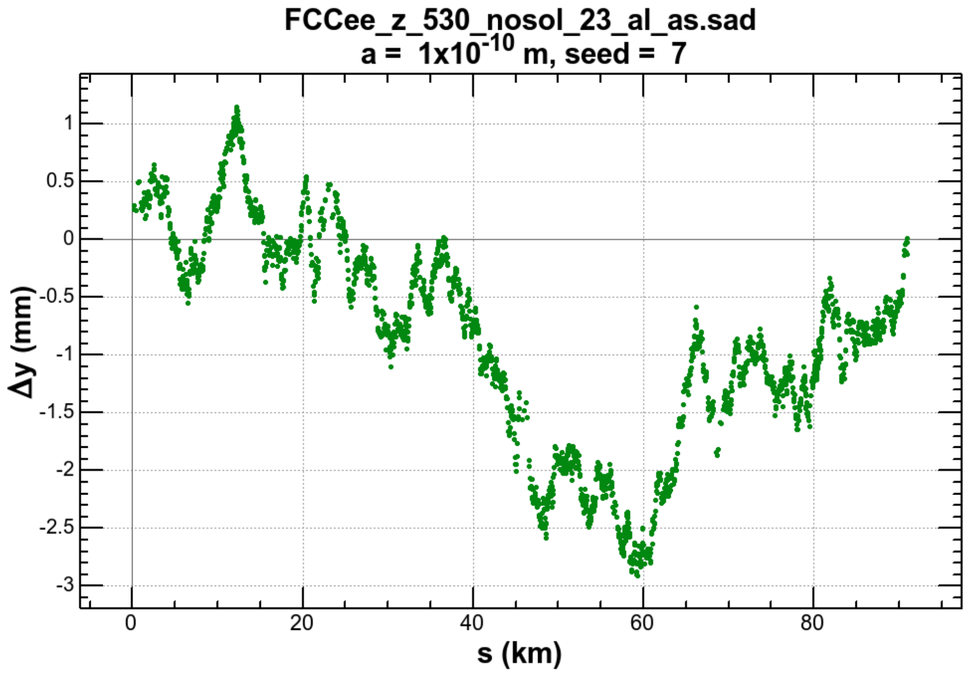
Many thanks to all FCC-ee/FCCIS colleagues

Motivations

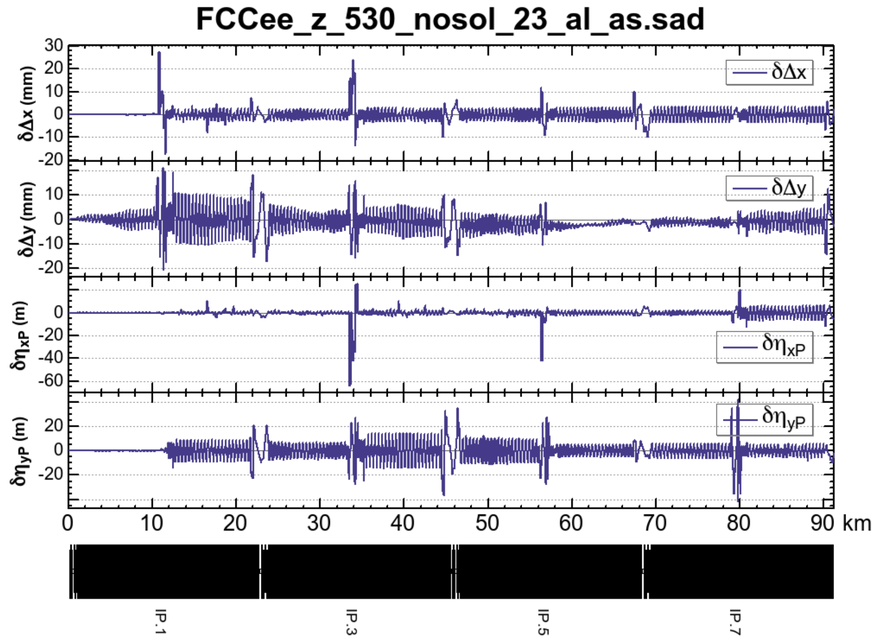
- Accumulation of alignment errors along the tunnel may be inevitable.
  - Even water levels or GPS cannot detect such kind of large scale errors.
  - Similar misalignments have been reported by S. Liuzzo in this workshop, in the ESRF accelerator hall.
- Here we assume $\left\langle \Delta y^2 \right\rangle = a\Delta s$, where Δs is the difference of s between two components.
  - Let us use a number $a = 10^{-10}\,\mathrm{m}$, or $\left\langle \Delta y^2 \right\rangle = (100\,\mu\mathrm{m})^2/(100\,\mathrm{m})$.
  - This has a similarity with the ATL Law (V. Shiltsev, *Phys.Rev.Lett.* 104 (2010) 238501).
    - LEP: $A = (3 \pm 0.6) \times 10^{-18}\,\mathrm{m/s}$. The a above corresponds to about 1 year change at LEP.

An example:

- FCC-ee Z optics, 4 IP, $C = 91\,\mathrm{km}$.
- Vertical misalignment of all quads and sexts, except IP quads “QC{12}*”.



Resulting single-pass orbit,
closed orbit not found.

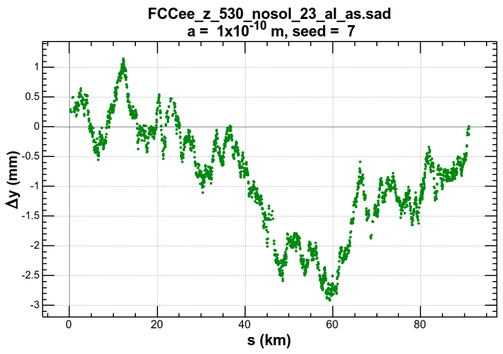


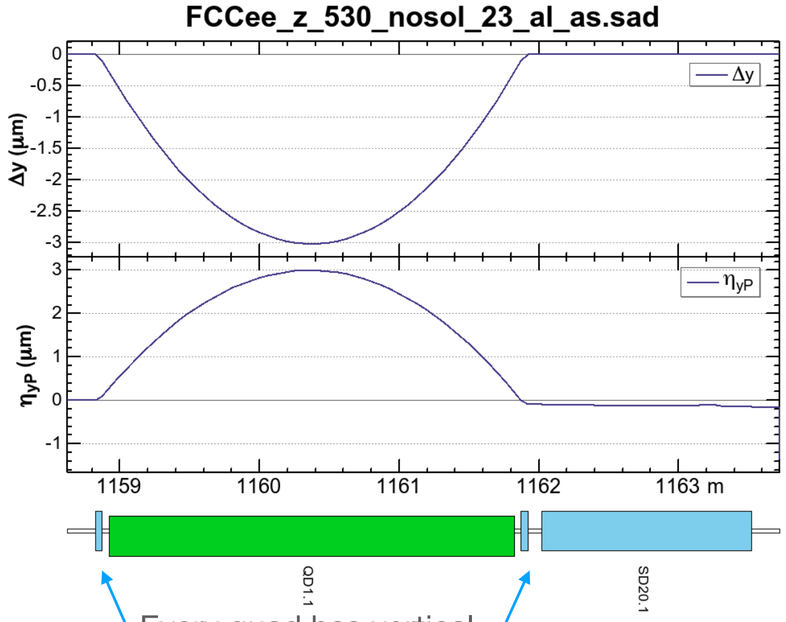
The horizontal orbit appears only due to the sextupoles.

There is a trivial (cheated) solution

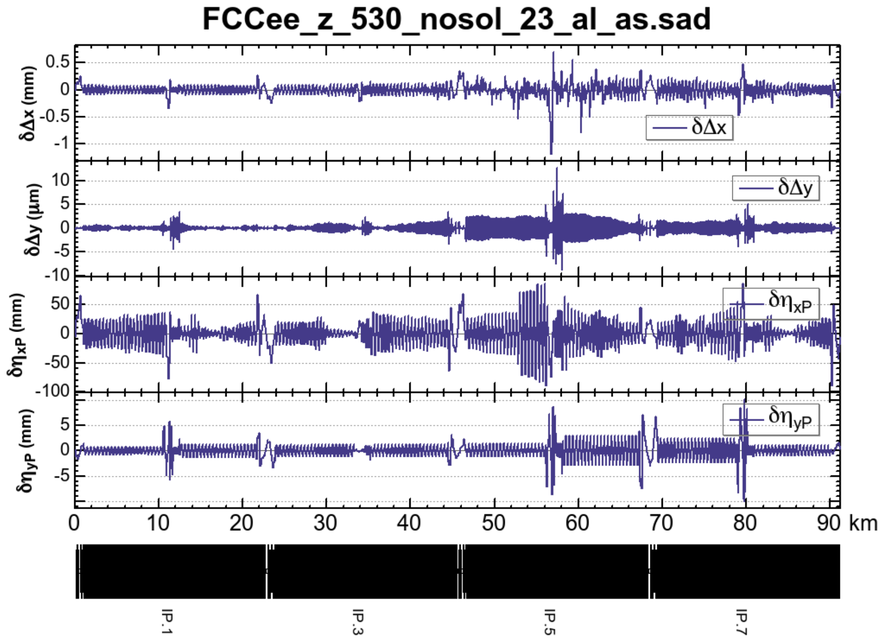
- If all quads are accompanied by vertical correctors at the both side,
  - also all sexts have skew quad trim windings.
- By setting their expected values from the misalignments, the closed orbit and optics are simply restored.
  - The resulting vertical emittance is <u>0.06 pm</u>.

The vertical orbit can be localized after the cheated correction.
The vertical dispersion still leaks, by a small amount.



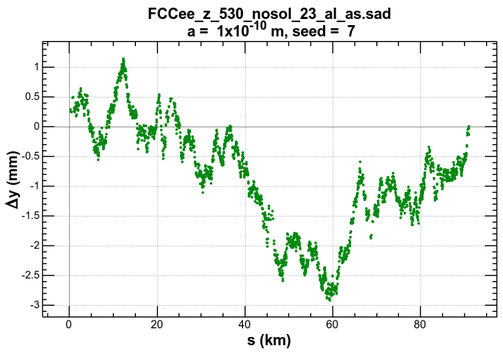


Every quad has vertical correctors at the both ends.

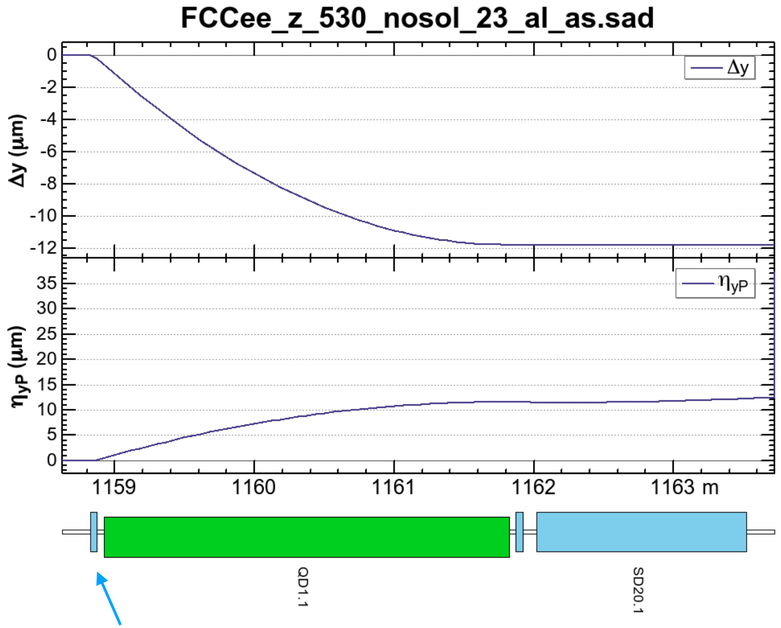


No such a trivial solution with singlet correctors

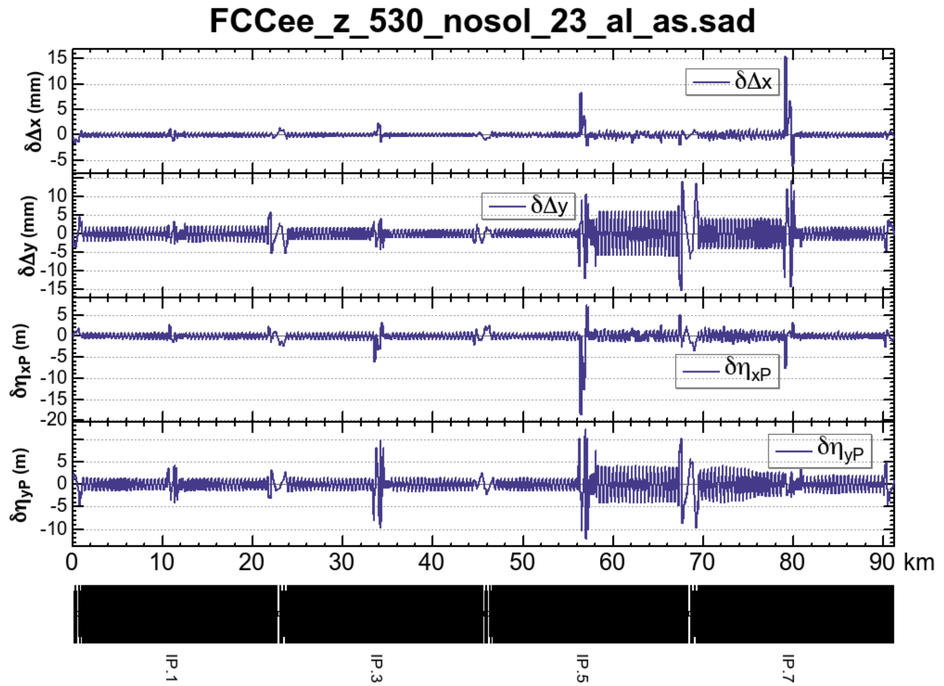
- It is not possible to localize the corrected orbit, if the corrector is located only at one side of a quad.
- If an angle-only correction is applied, the optics becomes stable, but the resulting dispersions are huge (a few meters).
  - The vertical emittance becomes 1.1 nm.



The vertical orbit and dispersion cannot be localized.



The corrector is located only at one side of a quad.



Summary

- A global accumulation of misalignment has a sizable effect on beam optics.
- If all quads have orbit correctors at the both ends, at least a solution exists.
  - All sexts have skew quad windings.
  - It is another question that how such a solution is practically reachable, esp. under other machine errors.
  - Superconducting quads with overlapped correctors have the same merit.
- If the corrector is one-sided, the existence of a solution satisfying the optics and emittance requirements is not trivial.